XVIII. *An Account of ſome late fiery Meteors; with Obſervations. In a Letter from* Charles Blagden, *M. D. Phyſician to the Army, Sec. R. S. to Sir* Joſeph Banks, *Bart. P. R. S.*

Read February 19, 1784.

TO SIR JOSEPH BANKS, BART. P. R. S.

DEAR SIR,

FROM the papers you were ſo good as to put into my hands, together with ſuch other information as I could procure, the following account of the two moſt remarkable of the late meteors is collected. I am ſenſible, that it is in many reſpects very imperfect; yet ſtill it gives a more ſatisfactory idea of the phænomena than can well be acquired from the relation of any ſingle obſerver, and therefore may not be diſagreeable to the learned Society over which you ſo worthily preſide, if no more perfect account ſhall previouſly have been laid before them.

Theſe meteors were of the kind known to the ancients by the names of Λαμπαδες, Πιθοι, Bolides, Faces, Globi, &c. from particular differences in their ſhape and appearance, and ſometimes, I believe, under the general term of Comets *; in the Philoſophical

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* ARISTOTLE's remark, that all the comets ſeen among them diſappeared without ſetting, Ἁπαντες οἱ καθ' ἡμας ωμμενοι (Κομηται) ανευ δυσεως ηφανισθησαν εν τῳ ὑπερ τȣ ὁριζοντος τοπῳ (Meteor. lib. I. c. 6.), ſeems ſcarcely applicable but to tranſitory meteors; and many other expreſſions to the ſame purpoſe occur in that author, PLINY,

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Philoſophical Tranſactions they are called indiſcriminately fire-balls or fiery meteors; and names of a ſimilar import have been applied to them in the different languages of Europe.

The moſt material circumſtances obſerved of ſuch meteors may be brought under the following heads. 1. Their general appearance. 2. Their path. 3. Their ſhape or figure. 4. Their light and colours. 5. Their height. 6. Their noiſe. 7. Their ſize. 8. Their duration. 9. Their velocity.

I ſhall begin with the firſt of theſe meteors, that which was ſeen on the 18th of Auguſt.

§ 1. Its general appearance in theſe parts of Great Britain was that of a luminous ball, which roſe in the N.N.W. nearly round, became elliptical and gradually aſſumed a tail as it aſcended, and in a certain part of its courſe ſeemed to undergo a remarkable change compared to burſting; after which it proceeded no longer as an entire maſs, but was apparently divided into a great number or a cluſter of balls, ſome larger than the others, and all carrying a tail or leaving a train behind; under this form it continued its courſe with a nearly equable motion, dropping or caſting off ſparks, and yielding a prodigious light, which illuminated all objects to a ſurpriſing degree; till having paſſed the eaſt, and verging conſiderably to the ſouthward, it gradually deſcended, and at length was loſt out of ſight. The

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PLINY, &c. SENECA himſelf, though he conceived diſtinctly enough the difference between comets and fiery meteors, yet evidently did not know where to draw the line (compare lib. I. and VII. Quæſt. Natur.). Even in modern times, theſe meteors have ſtruck ſpectators at firſt as comets (Fritzes Mediziniſche Annalen, vol. I. p. 77.); nay, expert aſtronomers, as appears by a letter from NATHANIEL PIGOTT, Eſq. F. R. S. lately read before the Royal Society. See alſo Mem. de l'Ac. des Scienc. 1771, p. 688. I have inſiſted the more on a ſubject apparently of ſo little conſequence, in order to account for the ſtrange opinions of the ancients reſpecting comets, which, I think, proceeded chiefly from confounding them with theſe fiery meteors.

time of its appearance was 9 h. 16′ P.M. mean time of the meridian of London, and it continued viſible about half a minute.

§ 2. How far north the meteor may have begun I have no materials to determine with preciſion; but, as it was ſeen in Shetland, and at ſea between the Lewes and Fort William, and appeared to perſons at Aberdeen and Blair in Athol aſcending from the northward, and to an obſerver in Edinburgh as riſing like the planet Mars, there can be little doubt but its courſe commenced beyond the fartheſt extremity of this iſland, ſomewhere over the northern ocean. General MURRAY, F. R. S. being then at Athol Houſe, ſaw it paſs over his head as nearly vertical as he could judge, tracing it from about 45° of elevation north-north-weſtward to 30° or 20° ſouth-ſouth-eaſtward, where a range of buildings intercepted it from his view. From near the zenith of Athol Houſe, it paſſed on a little weſtward of Perth, and probably a little eaſtward of Edinburgh; and continuing its progreſs over the ſouth of Scotland, and the weſtern parts of Northumberland and the Biſhopric of Durham, proceeded almoſt through the middle of Yorkſhire, leaving the capital of that county ſomewhat to the eaſtward. Hitherto its path was as nearly S.S.E. as can be aſcertained; but ſomewhere near the borders of Yorkſhire, or in Lincolnſhire, it appears to have gradually deviated to the eaſtward, and in the courſe of that deviation to have ſuffered the remarkable change already noticed under the denomination of burſting. After this diviſion, the compact cluſter of ſmaller meteors ſeems to have moved for ſome time almoſt S.E. thus traverſing Cambridgeſhire and perhaps the weſtern confines of Suffolk; but gradually recovering its original direction, it proceeded over Eſſex and the Straits of Dover, entering the continent probably not far from Dunkirk, where, as well as at Calais and Oſtend, it was thought to be vertical. Afterwards it was ſeen at Bruſſels, Paris, and Nuits in Burgundy *, ſtill holding on its courſe to the ſouthward; nay, I have met with an intimation, though of doubtful authority †, that it was perceived at Rome. Our information of its progreſs over the continent is, indeed, very defective and obſcure; nevertheleſs, I think, we have ſufficient proof that it traverſed in all 13 or 14 degrees of latitude, deſcribing a track of 1000 miles at leaſt over the ſurface of the earth; a length of courſe far exceeding the utmoſt that has been hitherto aſcertained of any ſimilar phænomenon.

To adduce the different accounts from which this path is determined, would not only be inſufferably tedious, but contrary to the intention of this letter, which is to give a ſummary view of the whole. They are contained partly in letters, and partly in the different news-papers of England and Scotland, moſt of which have been peruſed for this purpoſe. The information derived from the news-papers, however incorrect in the detail, is brought to ſome degree of certainty by the check of comparing them with one another; and their frequent publication in moſt places of conſequence in this iſland, procures us advantages on the occaſion of ſuch extraordinary phænomena, not enjoyed in former ages, nor even now, to the like extent, in any other part of the world.

It ſeems ſcarcely more intereſting to trace the path of theſe bodies with minute preciſion, than it would be to mark the progreſs of a cloud's ſhadow upon the ground; but it is of conſequence to their theory to aſcertain well the direction of their courſe; and their deviations from a ſtraight line, as implying ſome particular cauſe, ſhould be carefully noticed. I have

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* Journ. de Paris, Août 24, 1783.

† PARKER's General Advertiſer, October 7, 1783.

have ventured to aſcribe ſuch a deviation to this meteor, from the concurrent teſtimony of many obſervers, who ſpeak in the plaineſt terms of a manifeſt change in its courſe about the time it was ſeen to burſt; and their evidence is confirmed by drawing a line S.S.E. from that part of Scotland to which the meteor was vertical, for ſuch a line is found to correſpond with its path as far as Yorkſhire, but in the ſouthern parts of the kingdom falls a great deal too much to the weſtward. That it afterwards reſumed its former courſe is rendered probable from the teſtimony of the obſervers in Kent, who almoſt uniformly mention its diſappearance in the S.S.E. as well as from the remarks made by ſeveral perſons near the metropolis, that when it attained its greateſt elevation, it bore but one or two points to the northward of eaſt.

§ 3. This meteor was deſcribed by moſt ſpectators under three different forms, and is thus repreſented by Mr. SANDBY in his beautiful Drawing*; but the two firſt of thoſe do not imply any real variation in its ſhape, depending only on a difference in the point of view. Accordingly, in the firſt part of its courſe over Scotland, it was ſeen to have a tail, and is thus deſcribed by General MURRAY when it paſſed Athol Houſe. Two cauſes concur in this deception; firſt, the fore-ſhortening, and even occultation, of the tail, when the object is ſeen nearly in front; and, ſecondly, that the light of moſt part of the tail is of ſo inferior a kind, as to be difficultly perceived at a great diſtance, eſpecially when the eye is dazzled by the overpowering brilliancy of the body. The length and ſhape of the tail, however, were perpetually varying; nor did the body continue always of the ſame magnitude and figure, but was ſometimes round, at other times elliptical, with a blunt or

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[*] Since engraved. See alſo the figures tab. IV. of this volume.

pointed protuberance behind. From ſuch changes of figure in this and other meteors it is, that they have been compared to columns or pyramids of fire, comets, barrels, bottles, flaſks, paper-kites, trumpets, tadpoles, glaſs-drops, quoits, torches, javelins, goats, and many ſimilar objects; whence the multifarious appellations given to them by the ancients were borrowed.

Reſpecting the tails of meteors, it is here neceſſary to diſtinguiſh between two different parts of which they conſiſt. The brighteſt portion ſeems to be of the ſame nature as the body, and indeed an elongation of the matter compoſing it; but the other, and that commonly the largeſt portion, might more properly be called the train, appearing to be a matter left behind after the meteor has paſſed; it is far leſs luminous than the former part, and often only of a dull or duſky red colour. A ſimilar train or ſtreak is not unfrequently left by one of the common falling ſtars, eſpecially of the brighter ſort; and veſtiges of it ſometimes remain for ſeveral minutes. It often happens, that even the large fire-balls have no other tail but this train, and ours of the 18th of Auguſt appeared at times to be in that ſtate; its tail was likewiſe thought by ſome ſpectators to be ſpiral.

Under this changeable form, but ſtill as a ſingle body, it proceeded regularly till a certain period, when expanding with a great increaſe of light, it ſeparated into a cluſter of ſmaller bodies or ovals, each extended into a tail and producing a train. At the ſame time a great number of ſparks appeared to iſſue from it in various directions, but moſtly downward, ſome of which were ſo bright as alſo to leave a ſmall train. Moſt fire-balls have ſuffered a burſting or exploſion of this kind; but in general they have been thought to diſappear immediately afterwards. *This*, however, continued its courſe, becoming more compact, or perhaps re-uniting, and ſeems to have undergone other ſimilar exploſions before it left our iſland, and again upon the continent*. The different accounts tend to ſhew, that its firſt ſeparation or burſting happened ſomewhere over Lincolnſhire, perhaps near the commencement of the fens. Many obſervers did not get ſight of it till after this period, and therefore never deſcribe it as a ſingle ball. There appears to be ſome deception, in conſequence of which ſpectators are led to believe, that a meteor is extinguiſhed by theſe exploſions; for the ſame opinion was formed of this in ſeveral parts of this courſe, though we have ſuch deciſive evidence of its continued progreſs; whether it be that the meteors really become more dull for a time immediately after their exploſion, or merely appear ſo on account of the greater preceding light, ſince they are always deſcribed as being moſt luminous the inſtant they burſt.

It is obſervable, that the great change in this meteor correſponds with the period in which it ſuffered a deviation from its courſe, as if there was ſome connexion between thoſe two circumſtances; and there are traces of ſomething of the ſame kind having happened to other meteors. If the exploſion be any ſort of effort, we cannot wonder that the body ſhould be moved by it from a ſtraight line; but on the other hand it ſeems equally probable, that if the meteor be forced, by any cauſe, to change its direction, the conſequence ſhould be, a diviſion or ſeparation of its parts.

§ 4. Nothing relative to theſe meteors ſtrikes the beholders with ſo much aſtoniſhment as the exceſſive light they afford, ſufficient to render very minute objects viſible upon the ground in the darkeſt night, and larger ones to the diſtance of many miles from the eye. The illumination is often ſo great as totally to obliterate the ſtars, to make the moon look dull, and even to affect the ſpectators like the ſun itſelf; nay, there are many inſtances in which ſuch meteors have made a ſplendid appearance in full ſun-ſhine. The colour of their light is various and changeable, but generally of a bluiſh caſt, which makes it appear remarkably white. A curious effect of this was obſerved at Bruſſels the 18th of Auguſt, that whilſt the meteor was paſſing, "the moon appeared quite red, but ſoon "recovered its natural light*." The brightneſs alone of the meteor is not ſufficient to explain this, for the moon does not appear red when ſeen by day; but it muſt have depended on the the contraſt of colour, and ſhews how large a proportion of blue rays enters into the compoſition of that light, which could make even the *ſilver* moon appear to have exceſs of red. Priſmatic colours were alſo obſerved in the body, tail, and ſparks of this meteor, variouſly by different perſons; ſome compared them to the hues of gems. The moment of its greateſt brightneſs ſeems to have been when it burſt the firſt time; but it continued long to be more luminous after that period, than it was before.

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* For another inſtance of repeated exploſions conſult Mem. de l'Ac. des Scienc. 1756, p. 23.

The body of the fire-ball, even before it burſt, did not appear of an uniform ſubſtance or brightneſs, but conſiſted of lucid and dull parts, which were perpetually changing their reſpective poſitions; ſo that the whole effect was to ſome eyes like an internal agitation or boiling of the matter, and to others like moving chaſms or apertures. Similar expreſſions have been uſed in the deſcription of former meteors. The luminous ſubſtance was compared to burning brimſtone or ſpirits, Chineſe fire, the ſtars of a rocket, a pellucid ball or bubble of fire, liquid pearl, lightning and electrical fire; few perſons fancied it to be ſolid, eſpecially when it came near the zenith. Different ſpectators obſerved the light of the meteor to ſuffer at times a ſudden diminution and revival, which produced an appearance as of ſucceſſive inflammation; but might, in ſome caſes at leaſt, be owing to the interpoſition of ſmall clouds in its path.

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* From a letter of the Abbé MANN's, Director of the Academy at Bruſſels, to Sir JOSEPH BANKS, Bart. P. R. S.

§ 5. When, in conſequence of a more accurate attention to natural philoſophy, ſuch obſervations were firſt made upon fire-balls as determined their height, the computers were with reaſon ſurpriſed to find them moving in a region ſo far above that of the clouds and other familiar meteors of our atmoſphere; eſpecially as to every uninformed ſpectator they appear extremely near, or as if burſting over his head, a natural effect of their great light when ſeen without intervening objects. Their real height is to be collected from obſervations made at diſtant ſtations, which, for the greateſt accuracy, ought to be ſo ſituated, that the line joining them may cut the path of the meteor at right-angles, and that, at its greateſt elevation, it may appear from both of them about 45° above the horizon, on oppoſite ſides of the zenith. Alſo two ſtations on the ſame ſide of its path, if the leaſt angle of elevation be not very ſmall, and the difference between that and the greateſt angle be conſiderable, are by no means to be rejected. But little reliance can be placed upon obſervations of a meteor's altitude at any ſuppoſed period of its courſe, ſuch as the moment of its burſting; becauſe thoſe changes are ſeldom ſo inſtantaneous,

ſtantaneous, or ſeen ſo much alike by different ſpectators, as to be marked with ſufficient certainty.

Even in proper ſtations it rarely happens, that the angle of elevation can be obſerved with that degree of accuracy, which is neceſſary for any certain determination of the height. An eſtimate by the eye is doubtful, not only on account of the flattened curve the ſky ſeems to deſcribe, for which the moſt experienced obſervers ſcarcely ever make a juſt allowance, but likewiſe of the emotion produced by ſuch an unexpected, magnificent, and perhaps alarming ſpectacle, which renders it almoſt impoſſible to be quite collected. Therefore, unleſs an obſervation be checked by means of a houſe, tree, or ſome fixed body, along which the meteor was found to range, it muſt be received as uncertain. By night the ſtars afford excellent marks, eſpecially if the time be known with exactneſs; the brighter meteors, indeed, render theſe faint lights inviſible for the moment, but here we derive an eminent advantage from the train, which remains after the meteor is gone, and delineates perfectly its track through the heavens. If no ſuch marks have been taken, the expedient of endeavouring to recollect the part of the ſky where it paſſed, and aſcertaining that height with a quadrant, may often be uſeful; but there are many men of ſuch a turn of mind, that the original impreſſion made upon them will be totally perverted by their own ſubſequent reflexions and the remarks of others; in which caſe ſuch an application of inſtruments is likely to give a reſult farther from the truth, than their firſt immediate judgement, however vague and hazarded.

I am ſorry to add, that moſt of the obſervations in my poſſeſſion of the meteor which appeared the 18th of Auguſt, give its altitude by eſtimation only; yet I hope their correſpondence with one another will gain them a degree of credit, to which, if ſingle, they would not be entitled.

1. In a letter from Perth in Scotland it is ſaid, that " a " gentleman, who has a very good eye, obſerved the meteor " paſs about 6° to the weſtward of the zenith ;" and a Profeſſor in one of the Univerſities, being at Ardoch on the banks of the Tweed, about two miles below Dunbarton, judged it to have " at leaſt 45° of elevation above the horizon." Theſe altitudes would make its real height 57 ſtatute miles.

2. At St. Andrew's in Scotland, " it was not quite vertical, " but according to ſome was 20° or 25° from the zenith, ac" cording to others not ſo much." Taking the greateſt of theſe diſtances as neareſt the truth, ſince we are uſually led to eſtimate altitudes greater than they really are, this obſervation, calculated with that of Ardoch, gives 60 miles for the height.

For the communication of theſe obſervations, collected by his friends, I am indebted to General MELVILL F. R. S.

At Edinburgh the meteor paſſed very near the zenith, in which caſe a deviation of a few degrees is ſcarcely perceptible to a common eye.

The rev. Mr. WATSON of Whitby, in a letter to Lord MULGRAVE V. P. R. S. is very confident, that the greateſt altitude of the meteor, which paſſed to the weſtward of his zenith, was 60°. Mr. EDGEWORTH F. R. S. in his letter to you, Sir, ſtates its elevation at Edgeworth's-Town near Mullingar, in Ireland, as 10° or 12° above the eaſtern horizon. Theſe obſervations, calculated ſtrictly from the latitudes and longitudes with the allowance for the curvature of the earth, as indeed were all the reſt where the difference would be ſenſible, give 57 miles for the height of the meteor.

4. In the Morning Chronicle of Sept. 19. is inſerted a letter from Newton Ardes, 7 miles eaſt of Belfaſt, in Ireland, correſponding ſo well with Mr. EDGEWORTH's in the deſcription of the meteor, as to appear very good authority. The altitude is there given as 16°, whence a height of 58 miles with the obſervation at Whitby.

5. Mr. MORE, Secretary to the Society for the encouragement of Arts, Manufactures, and Commerce, ſaw the meteor as he was riding about three miles S.W. of Broſeley in Shropſhire, and judged it to be elevated 35°. By a perpendicular drawn from this ſpot to its ſuppoſed path in Lincolnſhire, its height came out 59 miles.

6. The altitude of 25° determined at Windſor I take to be one of thoſe on which moſt reliance can be placed, becauſe the gentlemen preſent, two of them Fellows of the Royal Society, were remarkably well qualified for ſuch an eſtimation. The letter you received, Sir, from Profeſſor ALLAMAND of Leyden, mentions that the meteor was ſeen there about 30° above the horizon, and the terms in which it is deſcribed in the Dutch news-papers * agree with this account. Its height hence calculated appears to be 58 miles.

7. Mr. THOMAS SQUIRE, of Folkſtone, obſerved the meteor over his houſe, as he was in the poſture of leaning back againſt a hedge; he afterwards tried "its ranging with the roof by a "quadrant, and found it 68°½ above the horizon." Reducing this obſervation to the perpendicular dropped from Windſor on the path of the meteor, its height comes out 54 or 55 miles. Mr. SQUIRE's altitude, determined by a fixed object, is confirmed by the eſtimate of ſeveral perſons at Ramſgate.

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* Amſterdamiſche Courant, Aug. 28, 1783.

8. The meteor was ſeen by Mr. STEEVENS F. R. S. at Hampſtead near London, moving along over the top of a row of trees. Mr. CAVENDISH F. R. S. having taken the altitude of theſe trees with a quadrant, found that of the higheſt, as ſeen from the part of the garden-walk oppoſite to it, to be 33°; which correſponds very well with the other obſervations, and conſequently gives the ſame height for the meteor. Mr. STEEVENS kept his eye upon it conſtantly, whilſt he paſſed briſkly along the walk.

This agreement of the different altitudes is nearer than could be expected; yet I know of no contradictory obſervations of any authority, except ſome made near Plymouth and in Cornwall, where the meteor being pretty near the horizon, its altitude, as will commonly happen in ſuch caſes, is given too great. The effect of this, however, would be to ſhew, that the meteor was higher; and therefore, I think, we may ſafely conclude, that it muſt have been more than 50 miles above the ſurface of the earth, in a region where the air is at leaſt 30000 times rarer than here below.

Contrary to what has been aſſerted of moſt other fire-balls, this of the 18th of Auguſt appears by the preceding obſervations to have kept on in a parallel courſe, without any deſcent or approach toward the earth. It may be much queſtioned, whether ſuch a deſcent has been proved in any former inſtance. The meteor deſcribed by Sir JOHN PRINGLE has been cited as the moſt certain example; but any perſon who carefully examines the obſervations themſelves, as ſtated in the 51ſt volume of the Philoſophical Tranſactions, will find them totally inadequate for ſuch a concluſion; its height ſeems to me determined only in one part of its courſe, between Iſland-Bridge and Ancram, and was there from 48 to 50 miles [*]. M. LE ROY ſuppoſes the fire-ball ſeen July 17, 1771, to have been 54 miles high when it began, and 27 at its exploſion [†]; but does not give the facts on which his calculation is founded.

Every philoſopher muſt be ſtruck with the agreement of theſe meteors in their diſtance from the earth, juſt beyond the limits of our crepuſcular atmoſphere.

§ 6. That a report was heard ſome time after the meteor of the 18th of Auguſt had diſappeared, is a fact which reſts upon the teſtimony of too many witneſſes to be controverted, and is, beſides, conformable to what has been obſerved in moſt other inſtances. In general it was compared to the falling of ſome heavy body in a room above ſtairs, or to the diſcharge of one or more large cannon at a diſtance. That rattling noiſe, like a volley of ſmall arms, which has been remarked after other meteors, does not ſeem to have been heard on this occaſion. From a compariſon of the different accounts, it appears as if the report was loudeſt in Lincolnſhire and the adjacent countries, and again in the eaſtern parts of Kent; in the intermediate places it was ſo indiſtinct as generally not to have been noticed, and all obſervers of credit in Scotland deny that they heard any thing of the ſort. If, therefore, this report be connected with the burſting of the meteor, I ſhould be inclined to ſuppoſe, that ſound was produced two ſeparate times, namely at the firſt exploſion over Lincolnſhire, and again when it ſeemed to burſt ſoon after entering the continent. Ingenious men have availed themſelves of this ſound, to calculate the diſtance and height of meteors; and the exactneſs attained by this method, in the computation of the late fire-ball from the report heard at Windſor,

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[*] Phil. Tranſ. vol. LI. p. 241. and 274.

[†] Mem. de l'Acad. des Scienc. 1771, p. 676.

Windſor[*], is very remarkable; but in general the accounts diſagreed ſo much, that it would have been impoſſible to conclude any thing from them. Perhaps too the method itſelf is leſs certain than has been thought; for as the propagation of ſound, and with intenſity too, in air rarefied 30000 times, preſents great difficulties in theory, though it may be in ſome meaſure explicable from the vaſt bulk of the meteor, and the large quantity of this rare air it may therefore diſplace by a ſudden expanſion; I think it not improbable, that ſome hitherto unperceived circumſtance comes into play, by which the whole effect may be modified: for inſtance, if matter belonging to the meteor itſelf be what conveys the ſound to our lower atmoſphere, it may either admit ſound to be propagated through it at a different rate than through common air, or it may move much faſter than ſound travels, as the entire meteor certainly does, and carry on the ſonorific vibrations with it. Moreover, we cannot be ſure what is the velocity of ſound in air ſo much rarer than where our experiments have been made. For theſe reaſons, while we diſtruſt calculations of meteors founded on the progreſs of ſound, we ſhould be particularly careful to note down the intervals, and all the circumſtances, as they may lead to very curious diſcoveries. The effect of the noiſe is, frequently, to produce ſuch a ſhaking of the doors, windows, and the whole houſe, as is miſtaken for an earthquake.

Beſides the report as of exploſions which was heard *after* the meteor, another ſort of ſound was ſaid to *attend* it, more doubtful in its nature, and leſs eſtabliſhed by evidence; I mean, a kind of hiſſing, whizzing, or crackling, as it paſſed along. That ſound ſhould be conveyed to us in an inſtant from a body above 50 miles diſtant, appears ſo irreconcilable to all we know of philoſophy, that perhaps we ſhould be juſtified in imputing the whole to an affrighted imagination, or an illuſion produced by the fancied analogy of fireworks. The teſtimony in ſupport of it is, however, ſo conſiderable, on the occaſion of this as well as former meteors, that I cannot venture to reject it, however improbable it may be thought, but would leave it as a point to be cleared up by future obſervers.

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[*] See p. 111. of this volume.

§ 7. To determine the bulk of the fire-ball, we muſt not only have calculated its diſtance, but alſo know the angle under which it appeared. For this purpoſe the moon is the uſual term of compariſon; but as it was thought, at very different diſtances, to preſent a diſk equal to that luminary's, and the ſame expreſſions have been applied to moſt preceding fire-balls, I conceive this eſtimation rather to be a general effect of the ſtrong impreſſion produced by ſuch ſplendid objects on the mind, than to convey any determinate idea of their ſize. However, if we ſuppoſe its tranſverſe diameter to have ſubtended an angle of 30′ when it paſſed over the zenith, which probably is not very wide of the truth, and that it was 50 miles high, it muſt have been almoſt half a mile acroſs. The tail ſometimes appeared 10 or 12 times longer than the body; but moſt of this was train, and the real elongation behind ſeems ſeldom to have exceeded twice or thrice its tranſverſe diameter, conſequently was between one and two miles long. Now if the cubical contents be conſidered, for it appeared equally round and full in all directions, ſuch an enormous maſs, moving with extreme velocity, affords juſt matter of aſtoniſhment.

§ 8. The duration of the meteor is very differently ſtated, partly becauſe ſome obſervers had it in view a much longer time than others, and partly becauſe they formed different judgements of the time. Thoſe who ſaw leaſt of it ſeem to have perceived its illumination about ten ſeconds, and thoſe who ſaw moſt of it about a minute: hence the various accounts may in ſome meaſure be reconciled. Mr. HERSCHEL F. R. S. at Windſor, muſt have kept it in ſight long after other obſervers had thought it extinct: for though, probably, he did not ſee the beginning, as it never appeared to him like a ſingle ball, he watched it as much as "forty or forty-five "ſeconds, the laſt twenty or twenty-five of which it remained "almoſt in one ſituation, within a few degrees of the hori-"zon." This confirms the foreign accounts of its long progreſs to the ſouthward.

As ſcarcely any one had ſufficient preſence of mind to minute the time by his watch, the periods given for its duration are moſtly by gueſs. To correct this rude conjecture, it has been propoſed, that the obſerver ſhould endeavour to paſs over the time in his own mind as well as he can by recollection, whilſt another perſon ſilently marks the ſeconds with a watch. This may do ſomething, but ſtill leaves the matter very uncertain, as the nature of the emotion felt by the ſpectator while it was paſſing will cauſe the impreſſion of a longer or ſhorter time to be left upon his mind; and the formal proceſs of recollection is ſo tedious, that I believe the duration will in this way generally be made too ſhort. Mr. HERSCHEL, at my requeſt, was ſo good as to act over his obſervation, with the poſitions and geſtures he was obliged to employ; and this ſeems likely to come nearer the truth than a ſimple effort of the mind at recollection. But the ſureſt method would be, to repeat any uniform action in which the ſpectator might have been engaged at the time; as, for inſtance, to walk over the ſame ſpace of ground, that he paſſed while the meteor was in ſight.

§ 9. From the apparent motion of the meteor, compared with its height, ſome computation may be formed of its aſtoniſhing velocity. As at the height of 50 miles above the ſurface of the earth, it might be viſible from the ſame ſtation for a tract of more than 1200 miles, and the longeſt continuance of its illumination ſcarcely exceeded a minute, we have hence ſome preſumption that it moved not leſs than 20 miles in a ſecond. The rev. Mr. WATSON, in his letter to Lord MULGRAVE, ſays, *that the arc deſcribed by it whilſt in his view could not be leſs than* 70° *or* 80°, *and yet the time could not exceed* 4″ *or* 5″ *at moſt.* This, with an altitude of 60°, and height of 50 miles, gives for its velocity about 21 miles in a ſecond. The obſerver at Newton Ardes eſtimated its motion to be 10° *in a ſecond, at the altitude of* 16°; this would make its velocity 30 miles in a ſecond. Mr. HERSCHEL found it deſcribe *an arch of* 167° *during the* 40 *or* 45 *ſeconds he obſerved it*, which gives a velocity of more than 20 miles in a ſecond. Finally, Mr. AUBERT F. R. S. thought it deſcribed *an arch of* 136° *of azimuth in* 10 *or* 12 *ſeconds*, which would make its velocity above 40 miles in a ſecond. I am ſenſible of the objections that may be made to all theſe computations; undoubtedly they are too vague; and yet, all taken together, perhaps they may have ſome weight, eſpecially as they correſpond ſo well with the different phænomena of the meteor's duration, and other fire-balls have been computed to move as faſt *. Stating the velocity at the loweſt computation of 20 miles a ſecond, it exceeds that of ſound above 90 times, and begins to approach toward that of the earth in her annual orbit. At ſuch a rate, it muſt have paſſed over the whole iſland of Great Britain in leſs than half a minute, and might have reached Rome within a minute afterwards, or in ſeven minutes have traverſed the whole diameter of the earth!

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* See Mem. de l'Acad. des Scienc. 1771, p. 678. Phil. Tranſ. N° 341. and 360. and vol. LI. p. 263, &c.

From this calculation it will be evident, that there is little chance of determining the velocity of meteors from the times of their paſſing the zenith of different places; and that therefore we muſt principally depend on obſerving carefully, with a watch that ſhews ſeconds, their apparent velocity through the heavens.

THE fire-ball which appeared on the 4th of October, at 43 paſt ſix in the evening, was much ſmaller than that already deſcribed, and of much ſhorter duration. It was firſt perceived to the northward as a ſtream of fire, like the common ſhooting ſtars, but large; and having proceeded ſome way under this form, it ſuddenly burſt out into that intenſely bright bluiſh light which is peculiar to ſuch meteors. At this period I ſaw it, and can compare the colour to nothing I am acquainted with ſo well, as to the blue lights of India, and ſome of the largeſt electrical ſparks. The illumination was very great; and on that part of its courſe where it had been ſo bright, a duſky red ſtreak or train was left, which remained viſible perhaps a minute even with a candle in the room, and was thought by ſome gradually to change its form. Except this train, I think the meteor had no tail, but was nearly a round body, or perhaps a little elliptical. After moving not leſs than 10° in this bright ſtate, it became ſuddenly extinct, without any appearance of burſting or exploſion.

This meteor was ſeen for ſo ſhort a way, that it is ſcarcely poſſible to determine the direction of its courſe with accuracy; but as in proceeding to the eaſtward it very perceptibly inclined towards the horizon, it certainly moved ſomewhere from the north-weſtward to the ſouth-eaſtward. Its duration was ſo ſhort, that many perſons thought it paſſed in an oppoſite direction; for my own part, I found myſelf abſolutely unable to determine whether the motion was *from* or *toward* the S.E. Some ſpectators were of opinion, that it changed its courſe the moment it became bright, proceeding no longer in the ſame ſtraight line; but my information is not ſufficient to determine this queſtion.

My ſituation, Sir, was particularly fortunate for aſcertaining the height of this meteor, as I ſaw it from your Library, ranging immediately over the oppoſite roof of your houſe. Hence I find by a quadrant that its altitude, even when it became extinct, could not be leſs than 32°. The upper northernmoſt end of the train it left bore, as I judge by the compaſs, about 28° northward of true E. and the lower end about 14°. I have only one obſervation to compare with this, which was made by Mr. BOYS of Sandwich. He concludes, from the train I imagine, that "it diſappeared juſt under, and a very "little to the weſtward" (rather northward) "of, the ſtar "γ in the foot of Cepheus." At that time γ Cephei was about 57° high, and bore above 21° to the eaſtward of N. whence the height of the meteor above the ſurface of the earth, after all proper allowances are made*, muſt have been between 40 and 50 miles.

As there was no appearance of burſting at the extinction of this fire-ball, ſo no report was heard after it; nor did any ſound attend it.

Some obſervers thought *this* meteor alſo near as big as the moon, but to me it did not appear above one quarter of her diameter, which would make its breadth ſomewhat above a furlong.

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* It appears from obſervations taken by Gen. ROY, F. R. S. that the bearing of Sandwich from London is not ſo much to the ſouthward of eaſt, as it is laid down in our maps.

If the whole of the meteor's track be included, it ſeems to have laſted as much as three ſeconds, but in the bright ſtate its duration was leſs than two, I think not much above one. Suppoſing it deſcribed an arc of 14° in 1½ ſecond, or, according to Mr. AUBERT's obſervation, of 25° in 3″, its real velocity was about 12 miles a ſecond.

Such meteors as theſe, which paſs like a flaſh of lightning, and deſcribe ſo ſhort a courſe, are very unfavourable for calculating the velocity, but afford great advantages for determining the height, as they muſt be ſeen nearly at the ſame moment and in the ſame place by the different obſervers. Other inſtances are found of fire-balls beginning with a dull red light like a falling ſtar, particularly the great one of March 19, 1719, treated of ſo fully by Dr. HALLEY * and Mr. WHISTON †.

It is remarkable, that a ſimilar meteor had appeared the ſame day, that is, Saturday the 4th of October, about three in the morning, though, on account of the early hour, it was ſeen by fewer ſpectators. They repreſent it as riſing from the northward to a ſmall altitude, and then becoming ſtationary with a vibratory motion, and an illumination like day-light; it vaniſhed in a few moments, leaving a train behind. This ſort of tremulous appearance has been noticed in other meteors, as well as their continuing ſtationary for ſome time, either before they began to ſhoot forward, or after their courſe was ended.

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* Phil. Tranſ. vol. XXX. N° 350. p. 978.

† Account of a ſurpriſing meteor ſeen March 19, 1719.

I FIND it, Sir, impoſſible to quit this ſubject, without ſome reflexions about the cauſe, that can be capable of producing ſuch appearances at an elevation above the earth, where, if the atmoſphere cannot abſolutely be ſaid to have ceaſed, it is certainly to be conſidered as next to nothing. The firſt idea which ſuggeſted itſelf, that they were burning bodies projected with ſuch a velocity, was quickly abandoned, from the want of any known power to raiſe them up to that great height, or, if there, to give them the required impetus; and the ingenuity of Dr. HALLEY ſoon furniſhed him with another hypotheſis, in which he thought both theſe difficulties obviated. He ſuppoſes there is no projection of a ſingle body in the caſe; but that a train of combuſtible vapours, accumulated in thoſe lofty regions, is ſuddenly ſet on fire, whence all the phænomena are produced by the ſucceſſive inflammation *. But Dr. HALLEY gives no juſt explanation of the nature of theſe vapours, nor of the manner in which they can be raiſed up through air ſo extremely rare; nor, ſuppoſing them ſo raiſed, does he account for their regular arrangement in a ſtraight and equable line of ſuch prodigious extent, or for their continuing to burn in ſuch highly rarefied air. Indeed, it is very difficult to conceive, how vapours could be prevented, in thoſe regions where there is in a manner no preſſure, from ſpreading out on all ſides in conſequence of their natural elaſticity, and inſtantly loſing that degree of denſity which ſeems neceſſary for inflammation. Beſides, it is to be expected, that ſuch trains would ſometimes take fire in the middle, and ſo preſent the phænomenon of two meteors at the ſame time, receding from one another in a direct line.

Theſe difficulties have induced other philoſophers to relinquiſh Dr. HALLEY's hypotheſis, and propoſe, inſtead of it,

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* Phil. Tranſ. vol. XXX. N° 360.

one of a very oppoſite nature, that meteors are permanent ſolid bodies, not raiſed up from the earth, but revolving round it in very eccentric orbits; or, in other words, that they are terreſtrial comets *. The objections to this opinion, however, ſeem to me equally great. Moſt obſervers deſcribe the meteors, not as looking like ſolid bodies, but rather like a fine luminous matter, perpetually changing its ſhape and appearance. Of this many defenders of the opinion are ſo ſenſible, that they ſuppoſe the revolving body gets a coat or atmoſphere of electricity, by means of which it becomes luminous; but, I think, whoever carefully peruſes the various accounts of fire-balls, and eſpecially ours of the 18th of Auguſt when it divided, will perceive that their phænomena do not correſpond with the idea of a ſolid nucleus enveloped in a ſubtile fluid, any more than with the conjecture of another learned gentleman, that they become luminous by means of a contained fluid, which occaſionally explodes through the thick ſolid outer ſhell †.

A ſtrong objection to this hypotheſis of permanent revolving bodies, is derived from the great number of them there muſt be to anſwer all the appearances. Such a regular gradation is obſerved, from thoſe large meteors which ſtrike all beholders with aſtoniſhment, and occur but rarely, down to the minute fires called ſhooting ſtars, which are ſeen without being regarded in great numbers every clear night, that it ſeems impoſſible to draw any line of diſtinction between them, or deny that they are all of the ſame nature. But ſuch a crowd of revolving bodies could ſcarcely fail to announce their exiſtence by ſome other means than merely a luminous train in the night;

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* See a diſſertation on this ſubject by Profeſſor CLAP, of Yale College, New England.

† Phil. Tranſ. vol. LI. p. 267.

as, for inſtance, by meeting or juſtling ſometimes near the earth, or by falling to the earth in conſequence of various accidents; at leaſt we might expect they would be ſeen in the day-time, either with the naked eye of teleſcopes, by ſome of the numerous obſervers who are conſtantly examining the heavens. With regard to theſe falling ſtars, it were much to be wiſhed, that obſervations ſhould be made upon them by different perſons in concert at diſtant ſtations, for the purpoſe of aſcertaining their height and velocity; which would tend very much to illuſtrate all this part of meteorology.

Another argument of great weight againſt the hypotheſis that fire-balls are terreſtrial comets, is taken from their great velocity. A body falling from infinite ſpace toward the earth, would have acquired a velocity of no more than 7 miles a ſecond, when it came within 50 miles of the earth's ſurface; whereas theſe meteors ſeem to move at leaſt three times faſter. And this objection, if there be no miſtake in regard to the velocity of the meteors, as I think there is not, abſolutely overſets the whole hypotheſis.

What then can theſe meteors be? The only agent in nature with which we are acquainted, that ſeems capable of producing ſuch phænomena, is electricity. I do not mean that by what is already known of that fluid, all the difficulties relative to meteors can be ſolved, as the laws, by which its motions on a large ſcale are regulated in thoſe regions ſo nearly empty of air, can ſcarcely, I imagine, be inveſtigated in our ſmall experiments with exhauſted veſſels *; but only that ſeveral of the facts point out a near connexion and analogy with electricity, and that none of them are irreconcilable to the diſcovered laws of that fluid.

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* How nearly the phænomena of meteors have been repreſented by artificial electricity is known from a very remarkable experiment of Mr. ARDEN's. See PRIESTLEY, vol. V. p. 379.

1. Electricity moves with ſuch a prodigious velocity, as to elude all the attempts hitherto made by philoſophers to detect it; but the ſwiftneſs of meteors, ſtating it at 20 miles a ſecond, is ſuch as no experiments yet contrived could have diſcovered, and which ſeems to belong to electricity alone. This is, perhaps, the only caſe in which the courſe or direction of that fluid is rendered perceptible to our ſenſes, in conſequence of the large ſcale on which theſe fire-balls move.

2. Various electrical phænomena have been ſeen attending meteors. Lambent flames are deſcribed as ſettling upon men, horſes, and other objects *; and ſparks coming from them, or the whole meteor itſelf, it is ſaid, have damaged ſhips, houſes, &c. in the manner of lightning †. Theſe facts, I muſt own, are but obſcurely related, yet ſtill they do not ſeem to be deſtitute of foundation. If there be really any hiſſing noiſe heard while meteors are paſſing, it ſeems explicable on no other ſuppoſition than that of ſtreams of electric matter iſſuing from them, and reaching the earth with a velocity equal to that of the meteor, namely, in two or three ſeconds. Accordingly, in one of our late meteors, the hiſſing was compared to that of electricity iſſuing from a conductor ‡. The ſparks flying off ſo perpetually

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* Priestley's Hiſtory of Electricity, p. 352. Mem. de l'Acad. des Scienc. 1771, p. 681, 682. See an odd fact, perhaps of this nature, in Parker's General Advertiſer, Dec. 1, 1783.

† Mem. anc. de l'Acad. de Dijon, tom. I. Hiſt. p. 42. Phil. Tranſ. vol. XLVI. p. 366. Hiſt. de l'Acad. des Scienc. 1761, p. 28.

‡ Cheſter Weekly Courant, Auguſt 26, 1783. This and many other curious circumſtances, relative to meteors, are ſo well exemplified in the following obſervation, made ſeveral years ago by Mr. Robinson at Hinckley in Leiceſterſhire, that I think it worth tranſcribing here, eſpecially as it occurs in a work which few people would think of conſulting on ſuch a ſubject. "Oct. 26, "1766, at half paſt five in the evening, after a violent ſtorm of wind and rain,

perpetually from the body of fire-balls, may poſſibly have ſome connexion with theſe ſtreams *. In the ſame manner the ſound of exploſions may perhaps be brought to us quicker, than if it were propagated through the whole diſtance by air alone. Should theſe ideas be well founded, the change of direction which meteors ſeem at times to undergo, may poſſibly be influenced by the ſtate of the ſurface of the earth over which

“ I obſerved a fiery meteor. Its direction was from N.W. to S.E. nearly in a horizontal direction; it paſſed very near to me, and was of an elliptical form; its motion about 40° in 2″ or 3″ of time. It was very bright and lucid to appearance like the paleſt lightning, and emitted ſparks continually, which formed a kind of tail toward the N.W. which ſeemed to be extinguiſhed at the diſtance of 2° or 3° from the body; there was a ſmall portion that parted from it. The coheſion of matter was ſo great, that it drew a thread of conſiderable length from the body, before it broke from it. During the paſſage there was a kind of *hiſſing noiſe, much like to what we hear from the electrical machine when the electric matter is running away, or as when it is eſcaping from a full charged jar.*” Bibliotheca Topographica Britannica, N° VII. p. 81.

[*] Hiſt. de l'Acad. des Scienc. 1761, p. 28. Mem. de l'Acad. des Scienc. 1771, p. 682. Extract of a letter from the Abbé Mann, Director of the Academy at Bruſſels, to Sir Joseph Banks, Bart. P. R. S. “ I ſhall only mention one ſingular circumſtance, which was communicated to me by a particular friend of mine. It happened at Mariekercke, a ſmall village on the coaſt, about half a league to the W. of Oſtend. The curate of the village was ſitting in the duſk of the evening with a friend, when a ſudden light ſurpriſed them, and immediately after a ſmall ball of light-coloured flame came through a broken pane of glaſs, croſſed the room where they were ſitting, and fixed itſelf on the chink of a door oppoſite to the window where it entered, and there died gradually away. It appeared to be a kind of phoſphoric light, carried along by the current of air. The curate and his friend, greatly ſurpriſed at what they ſaw, apprehended fire in the neighbourhood; but going out, found that the fire, which had come in through the window, had been detached from a large meteor in its paſſage.”

How far theſe and ſimilar appearances may be owing ſimply to the illumination produced by meteors, ſhould be attentively conſidered in the inveſtigation of ſuch facts.

they are paſſing, and to which the ſtreams are ſuppoſed to reach. A ſimilar cauſe may occaſion the apparent exploſion, the opening of more channels giving new vent and motion to the electric fluid. May not the deviation and exploſion which appear to have taken place in the fire-ball of the 18th of Auguſt over Lincolnſhire, have been determined by its approach toward the fens, and an attraction produced by that large body of moiſture?

3. A further argument for the electric origin of meteors is deduced from their connexion with the northern lights, and the reſemblance they bear to theſe electrical phænomena, as they are now almoſt univerſally allowed to be, in ſeveral particulars. Inſtances are recorded, where northern lights have been ſeen to join and form luminous balls, darting about with great velocity, and even leaving a train behind like the common fire-balls *. This train I take to be nothing but the rare air left in ſuch a highly electrified ſtate as to be luminous; and ſome ſtreams of the northern lights are very much like it. The *aurora borealis* appears to occupy as high, if not a higher, region above the ſurface of the earth, as may be judged from the very diſtant countries to which is has been viſible at the ſame time †; indeed the great accumulation of electric matter ſeems to lie beyond the verge of our atmoſphere, as eſtimated by the ceſſation of twilight. Alſo with the northern

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* Hiſt. de l'Acad. des Scienc. 1705, p. 35. WHISTON's Account of a Meteor ſeen in the Air 171⅘. Phil. Tranſ. vol. XLI. p. 626; and LIII. p. 6? Alſo a moſt pointed fact in the Act. Liter. Sueciæ, 1734, p. 78.

† BERGMAN, upon a mean of 30 computations, makes the average height of the northern lights to be near 70 Swediſh, that is, about 460 Engliſh miles. Kong. Vetenſk. Acad. Handlingar, vol. XXV. p. 193. See alſo Phil. Tranſ. vol. LIV. p. 327. and M. DE MAIRAN's Traité de l'Aurore Boreale, p. 51.

lights a hiſſing noiſe is ſaid to be heard in ſome very cold climates; GMELIN ſpeaks of it in the moſt pointed terms, as frequent and very loud in the north-eaſtern parts of Siberia *; and other travellers have related ſimilar facts †.

But,

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* Reiſe durch Siberien, vol. III. p. 135. As the whole paſſage is very remarkable, and has never, that I know, appeared in Engliſh, I thought the following tranſlation of it might be acceptable.

"These northern lights begin with ſingle bright pillars, riſing in the N. and " almoſt at the ſame time in the N.E. which gradually increaſing comprehend a " large ſpace of the heavens, ruſh about from place to place with incredible velo- " city, and finally almoſt cover the whole ſky up to the zenith. The ſtreams are " then ſeen meeting together in the zenith, and produce an appearance as if a " vaſt tent was expanded in the heavens, glittering with gold, rubies, and ſap- " phire. A more beautiful ſpectacle cannot be painted; but whoever ſhould ſee " ſuch a northern light for the firſt time, could not behold it without terror. " For however fine the illumination may be, it is attended, as I have learned from " the relation of many perſons, with ſuch a hiſſing, cracking, and ruſhing noiſe " throughout the air, as if the largeſt fire-works were playing off. To deſcribe " what they then hear, they make uſe of the expreſſion, *Spolochi chodjat*, that is, " the raging hoſt is paſſing. The hunters who purſue the white and blue foxes " in the confines of the Icy Sea, are often overtaken in their courſe by theſe " northern lights. Their dogs are then ſo much frightened, that they will not " move, but lie obſtinately on the ground till the noiſe has paſſed. Commonly " clear and calm weather follows this kind of northern lights. I have heard this " account, not from one perſon only, but confirmed by the uniform teſtimony " of many, who have ſpent part of ſeveral years in theſe very northern regions, " and inhabited different countries from the Yeniſei to the Lena; ſo that no " doubt of its truth can remain. This ſeems indeed to be the real birth-place " of the *aurora borealis*."

It is here to be obſerved, that GMELIN did not collect the account himſelf, but extracted it from letters or papers of M. DE L'ISLE DE LA CROYERE's, who was himſelf far to the northward of Yakutſk, without hearing theſe noiſes; probably, therefore, it is much exaggerated, though one can ſcarcely ſuppoſe the whole to be fabulous.

† Muſſchenbroeck Introduct. § 2495. Beccaria dell' Elletriciſmo artif. et nat. p. 221.

But, in my opinion, the moſt remarkable analogy of all, and that which tends moſt to elucidate the origin of theſe meteors, is the direction of their courſe, which ſeems, in the very large ones at leaſt, to be conſtantly from or toward the north or north-weſt quarter of the heavens, and indeed to approach very nearly to the preſent magnetical meridian. This is particularly obſervable in thoſe meteors of late years whoſe tracks have been aſcertained with moſt exactneſs; as that of November 26, 1758, deſcribed by Sir JOHN PRINGLE; that of July 17, 1771, treated of by M. LE ROY; and this of the 18th of laſt Auguſt. The largeſt proportion of the other accounts of meteors confirm the ſame obſervation, even thoſe of a more early period[*]; nay, I think, ſome traces of it are per-

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p. 221. There is now working with Mr. NAIRNE F. R. S. a perſon of the name of ARNOLD, who reſided ſeven years at Hudſon's Bay, the laſt three at Fort Henley. He confirms M. GMELIN's account of the fine appearance and brilliant colours of the northern lights, and particularly of their ruſhing noiſe, which he affirms he has very frequently heard, and compares it to the ſound produced by whirling round a ſtick ſwiftly at the end of a ſtring. He adds, that on converſing about this matter with a Swediſh watch-maker of the name of LIND, that perſon aſſured him, that he had heard a ſimilar noiſe in his own country. Mr. NAIRNE too, one time, at Northampton, when the northern lights were remarkably bright, is confident he perceived a hiſſing or whizzing ſound.

This hiſſing or ruſhing noiſe, as well as that attending meteors in their paſſage, ſuppoſing it in both caſes to be real, I would attribute to ſmall ſtreams of electric matter, running off to the earth from the great maſſes or accumulations of electricity, by which I ſuppoſe both meteors and the northern lights to be produced. Compare M. DE MAIRAN's Traité de l'Aurore Boréale, p. 126.

[*] See Phil. Tranſ. and Mem. de l'Acad. des Sciences, &c. I have found, of an earlier or later period, accounts of more than 40 different fire-balls. Of theſe above 20 are ſo deſcribed, that it is certain their courſe was in the above-mentioned direction; only 3 or 4 ſeem to have moved the contrary way; and with regard to the remainder, it is left doubtful, from the imperfect ſtate of the relations.

perceivable in the writings of the ancients *. Whether their motion ſhall be *from* the northern quarter of the heavens or *toward* it, ſeems nearly indifferent, as the numbers of thoſe going each way are not very unequal; I conſider them, in the former caſe, as maſſes of the electric fluid repelled, or burſting from the great collected body of it in the north; and, in the latter caſe, as maſſes attracted toward that accumulation; a diſtinction, probably, much the ſame in effect, as that of poſitive and negative electricity near the ſurface of the earth.

This tendency toward the magnetic meridian, however, ſeems to hold good only with regard to the largeſt ſort of fire-balls; the ſmaller ones move more irregularly, perhaps becauſe they come further within the verge of our atmoſphere, and are thereby more expoſed to the action of extraneous cauſes. That the ſmaller ſort of meteors, ſuch as ſhooting ſtars, are really lower down in the atmoſphere, is rendered very probable by their ſwifter *apparent* motion; perhaps it is this very circumſtance which occaſions them to be ſmaller, the electric

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tions. When we conſider that even the meteor of the 18th of Auguſt laſt was thought by *ſome* ſpectators to move ſouth-weſtward, it will rather appear ſurpriſing that ſo many of theſe accounts ſhould correſpond, than that a few of them ſhould differ.

* ARISTOTLE (Meteor. lib. I. c. 6.) denies that comets, with which I take meteors to be confounded, are generated *only* in the north; which ſhews it to have been then the prevalent opinion, that they appeared moſt frequently in that quarter. Αλλα μην ουδε τουτο αληθες, ὁτι εν τῳ προς αρκτον τοπῳ γινεται ὁ Κομητης μονον. So likewiſe PLINY (lib. II. c. 25.) Xiphias, Diſceus, Pitheus doliorum cernuntur figura, in concavo fumidæ lucis. Ceratias. Lampadias. Hippeus. Candidus Comètes. Omnes ferme *ſub ipſo ſeptentrione*, aliquâ ejus parte non certâ, ſed maxime in candidâ, quæ lactei circuli nomen accepit. And SENECA (Quæſt. Nat. lib. VII.) Placet ergo noſtris, Cometas, ſicut Tubas, Trabeſque, et alia oſtenta cœli, denſo aëre creari. Ideo *circa ſeptentrionem frequentiſſimè apparent*, quia illic plurimum eſt aëris pigri.

fluid being more divided in more reſiſting air. But as thoſe maſſes of electricity, which move where there is ſcarcely any reſiſtance, ſo generally affect the direction of the magnetic meridian, the ideas which have been entertained of ſome analogy between theſe two obſcure powers of nature, ſeem not altogether without foundation *.

If the foregoing conjectures be juſt, diſtinct regions are allotted to the electrical phænomena of our atmoſphere. Here below we have thunder and lightning, from the unequal diſtribution of the electric fluid among the clouds; in the loftier regions, whither the clouds never reach, we have the various gradations of falling ſtars; till beyond the limits of our crepuſcular atmoſphere the fluid is put into motion in ſufficient

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* It appears to me more rational to reſolve this analogy into a power of electricity to influence magnetiſm, than into a ſuppoſed ſimilarity of two fluids; as the former can be made evident by our artificial experiments, but there is no proof of the latter. When fire-balls, therefore, are ſaid to affect the magnetic meridian, I do not mean that they are drawn in that direction becauſe it is the line of magnetiſm, but rather that the magnetic poles of the earth are thrown into their preſent poſition, by the accumulation and action of that very electricity upon which the fire-balls depend. Should a change be produced by any cauſe in the place of this accumulation, or the ſtate of its motion, it is not improbable, that the main polarity would be given to other portions of the earth, whence a variation in the pointing of the compaſs would neceſſarily enſue. If Dr. FRANKLIN's hypotheſis be admitted, aſcribing the electrical ſtate of the polar atmoſphere to the cruſt of ice (a bad conductor) in thoſe regions, it follows, that ſhould ice form or be collected in one part more than in another, the atmoſphere there would become more highly electrical, and, in ſo far as the magnetiſm is given by electricity, the adjoining portion of the earth would acquire a ſtronger polarity. Now it is certainly worthy of remark, that ſince our firſt northern navigations, the coaſt of Weſt Greenland and its ſurrounding ſeas have become gradually more and more inacceſſible on account of ice, and that the magnetic needle all this time has been conſtantly changing its variation to the weſtward.

maſſes to hold a determined courſe, and exhibit the different appearances of what we call fire-balls; and probably at a ſtill greater elevation above the earth, the electricity accumulates in a lighter leſs condenſed form, to produce the wonderfully diverſified ſtreams and coruſcations of the *aurora borealis.*

I have the honour to be, with the greateſt reſpect,

SIR,

Your moſt obedient humble ſervant,

C. BLAGDEN.

END OF PART I. OF VOL. LXXIV.